STAR Q316 and Q325 Transmission Loss Trial Data Re-analysis

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1 Introduction

The transmission loss data collected during Q316 and Q325 was reprocessed using the current version STAR.

Akoostix Inc. provided data processing, analysis, and sea-trial support for transmission loss (TL) measurement experiments performed during Canadian Forces Auxiliary Vessel (CFAV) Quest cruises Q316 and Q325. An overview of these experiments, along with detail describing the initial processing and analysis are contained in the related analysis contract reports [1],[2]. The Software Tools for Analysis and Research (STAR) software package, used for the processing and analysis of the TL data, are under continuous, iterative development; where newer software releases may cause or reveal errors in processing scripts originally tested using a previous version of the software.

This fixed-price contract was required to update the Q316 and W325 TL-data-analysis scripts to work correctly with the current version of STAR. This work included investigating and resolving software defects revealed during the re-analysis. The STAR Analysis Tools Subversion repository Trunk revision 11105 contains the software updates, which will be provided in the next STAR software release (Version 6.6.12).

1.1 Overview

This document contains:

- A list of the requirements for this contract
- A description of the issues encountered during data processing and analysis using the current version of STAR software
- A discussion of how the issues were resolved, as well as documentation of the changes to the software and processing scripts required for reprocessing the data
- A summary of the effort, as well as notes that may be useful during future analysis of experimental TL-measurement datasets

2 Requirements

This section documents issues that were discovered when DRDC began detailed analysis of the Q316 and Q325 TL-measurement datasets.

During reprocessing of the Q316 and Q325 TL-measurement datasets using the current version of STAR, the following issues were discovered and subsequently addressed under this contract:

- Correlation processing required replicas with a complex (imaginary) component to achieve the theoretical coherent processing gain.
  - A symptom related to this issue was documented during the initial analysis, but the cause was not identified until after the contract was complete.
- Timestamp parsing errors were discovered when using the new version of the STAR-IDL time library.
- Logged values for aspect bearing that did not agree with the experimental geometry.
- Continuous wave (CW) pulses were losing time lock during automated measurement.
- The following adjustments to the source level and calibration were required:
  - The originally-provided Q316 reference levels (volts/LSB [Least Significant Bit]) were incorrect.
  - The source levels for Q316 were not correctly calculated and logged.
  - It was unclear how the source-directivity correction was applied and the methodology required investigation.

These issues resulted from information that were invalid or missing during the initial analysis contracts, as well as configuration issues between the current version of STAR and the version used for the initial processing and analysis.

3 Issue resolution and software upgrades

This section describes how issues described in Section 2 were resolved and provides documentation of required software upgrades.

3.1 Correlation processing

This requirement was achieved by modifying the *make_replicas* scripts for each TL experiment to use the *complex-float* output type when generating replicas.

SPPACS had already been upgraded to use complex replicas for correlation processing.

A replica with both real and imaginary components provides an efficient method of enveloping the correlated data, while achieving a processing gain that is the product of the replica length and positive replica bandwidth.

3.2 STAR-IDL time library

A significant upgrade to the STAR-IDL time library was performed in FY11/12. The new time library uses absolute microsecond values for time computations instead of using individual calendar fields (year, day, hour, minute, second). The old time library could not take into account year and day in many of the calculations, where the new library does. The upgrade greatly improved the efficiency and functionality of the library, but now requires a reference time for some of the time-string parsing functions so the year and day can be accounted for.

The issue was rectified by adding a reference time field containing the day, month, and year of the data to all of the *auto_analysis** scripts, which allow STAR-IDL to properly parse the time-strings using the new time library.

3.3 Aspect bearing errors

The aspect bearings calculated during re-analysis did not agree with the experiment geometry. This issue revealed a flaw in the original analysis configuration, as only one source was defined, but it was not properly associated with the processed data. This association is normally achieved via a STAR *ping* definition, which should not be confused with the ping log specifically formatted for the TL analysis. The former associates processed active data with an acoustic source and is stored in the *NAD/ping* directory, while the latter ping log provides source level information and is stored in the *analysis_results* directory for the trial.

This issue was revealed after STAR-IDL upgrades to the NAD parsing software. A bug in older versions of STAR handled queries with empty strings poorly, in that tactical data could be accessed even if the requested track name was an empty string. The bug allowed for aspect-bearing calculations without having an acoustic-source-to-ping mapping defined, as data from all *sources* in the database were returned. Had more than one source been defined, the analysis may not have worked. The improved software does not return data for

queries with empty strings, and therefore the acoustic source and related STAR *ping* definitions are required.

To rectify the issue, a STAR-formatted ping-log, which maps each processed data directory (ping name) to a source, was added to the *NAD/ping/* directory of each experiment. This ensures that tactical queries will work correctly. The correct aspect bearing is now calculated.

3.4 CW pulses

The timing errors noticed in the automated-CW-pulse analysis logs were a result of upgrades to Signal Processing Packages (SPPACS) spectral-record time stamping. When generating spectral data, each record of output is generated using multiple input data points (FFT window), which causes ambiguity as to which time should be associated with each output record. The time offsets in the *auto_cw_analysis* for each experiment were adjusted to be consistent with current SPPACS handling of spectral processing timestamps.

3.5 Calibration and source-level adjustments

DRDC noted that the reference level provided for the initial Q316 SHARPS recorder analysis was incorrectly estimated. The value was changed from 7.019043e-5 V/LSB to 5.61423e-5 V/LSB in the ref_edit.sh for both Q316 TL experiments.

There was also concern about whether or not the directivity of the source was applied to adjust the source level. The source-level value in the transmission-loss-data container was identical to the source level in the ping logs, which caused confusion. Investigation revealed that the source level was stored with the ping logs, separate from the source beam pattern, and only the source level was used for the data container. The source-directivity correction was applied later, along with the other processing calibrations during calculation of the level field, thus there was not an issue that needed to be resolved.

DRDC suspected that the source levels, initially provided for the Q316 analysis, were incorrect. The source levels were re-calculated by the project authority and the pinglog.txt contained in the *analysis_results* directory was patched to match the new values. There are still some discontinuities in the TL plots, indicating that some of the source-level timestamps are still incorrect.[1]

Another source-level calibration that converts the source level to total pulse energy might be required to convert the source-level units to match the other calibrated measurements. This calibration factor is a constant, and can be directly applied to the ping logs if it is determined that it is required.

[1] During QA of the original Q316 analysis, discontinuities were also discovered in the processed data. A detailed analysis at that time revealed that the source level changed at times other than those reported in the logs that were provided. The times of source level changes were manually adjusted to agree with the observed changes in the data. DRDC should confirm that the new source level logs do not also contain this issue.

4 Summary

The data from the Q316 and Q325 TL-measurement experiments were reprocessed and the automated analysis was repeated. The issues described in Section 2 were remedied, as documented in Section 3. The STAR and trial analysis SVN repositories were updated, and the reprocessed data and analysis logs were delivered to the project authority on an external hard drive.

The following notes may be useful in future analysis of the TL data:

- The source-level-log times for the Q316 Sept15 are likely incorrect, as there are some discontinuities in the transmission loss plots. This issue may relate to previous changes discussed in the footnote for Section 3.5.
- An additional source-level-correction factor, which converts the source level to total energy in the pulse, may need to be applied.
- The FM pulses were reanalyzed with the multipath flags turned on (see [1] for a description of the multipath analysis algorithm).
    - Each echo measurement has a descriptor indicating its arrival order. The descriptor is located in the *echo_data.data_hdr.active_display_type* field in the transmission loss container.
    - The *auto_fm_analysis* scripts in the *idlprog* can be re-run with the multipath flag set to zero if multipath information is not required. The multipath flag in the scripts was added under this contract to simplify configuration management.

Annex A Acronyms

CFAV	Canadian Forces Auxiliary Vessel
CR	Contract Report
CW	Continuous Wave
DRDC	Defence Research and Development Canada
FFT	Fast Fourier Transform
FM	Frequency Modulation
IDL	Interactive Data Language
LSB	Least Significant Bit
NAD	Non-Acoustic Data
SPPACS	Signal Processing Packages
STAR	Software Tools for Analysis and Research
STAR-IDL	IDL specific applications of STAR
SVN	Subversion
TL	Transmission Loss

Annex B References

[1] Hood, J., and Bougher, B. (2009), Transmission Loss Data Analysis on Q316 Trial Data (AI CR 2009-008), Akoostix Inc., Dartmouth, Nova Scotia.

[2] Bougher, B., and Hood, J. (2010), Q325 Trial Support Version 2.0 (AI CR 2009-010), Akoostix Inc., Dartmouth, Nova Scotia.